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Van Bortel

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[54] **BINDING APPARATUS**

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[51] **Int. Cl.**^{4} **B42C 13/00**

[52] **U.S. Cl.** **56/384;** 156/216; 156/475; 156/908; 412/33; 412/900; 412/902

[58] **Field of Search** 156/216, 475, 908, 384; 412/4, 8, 19, 33, 36, 37, 900, 902

[56] **References Cited**

U.S. PATENT DOCUMENTS

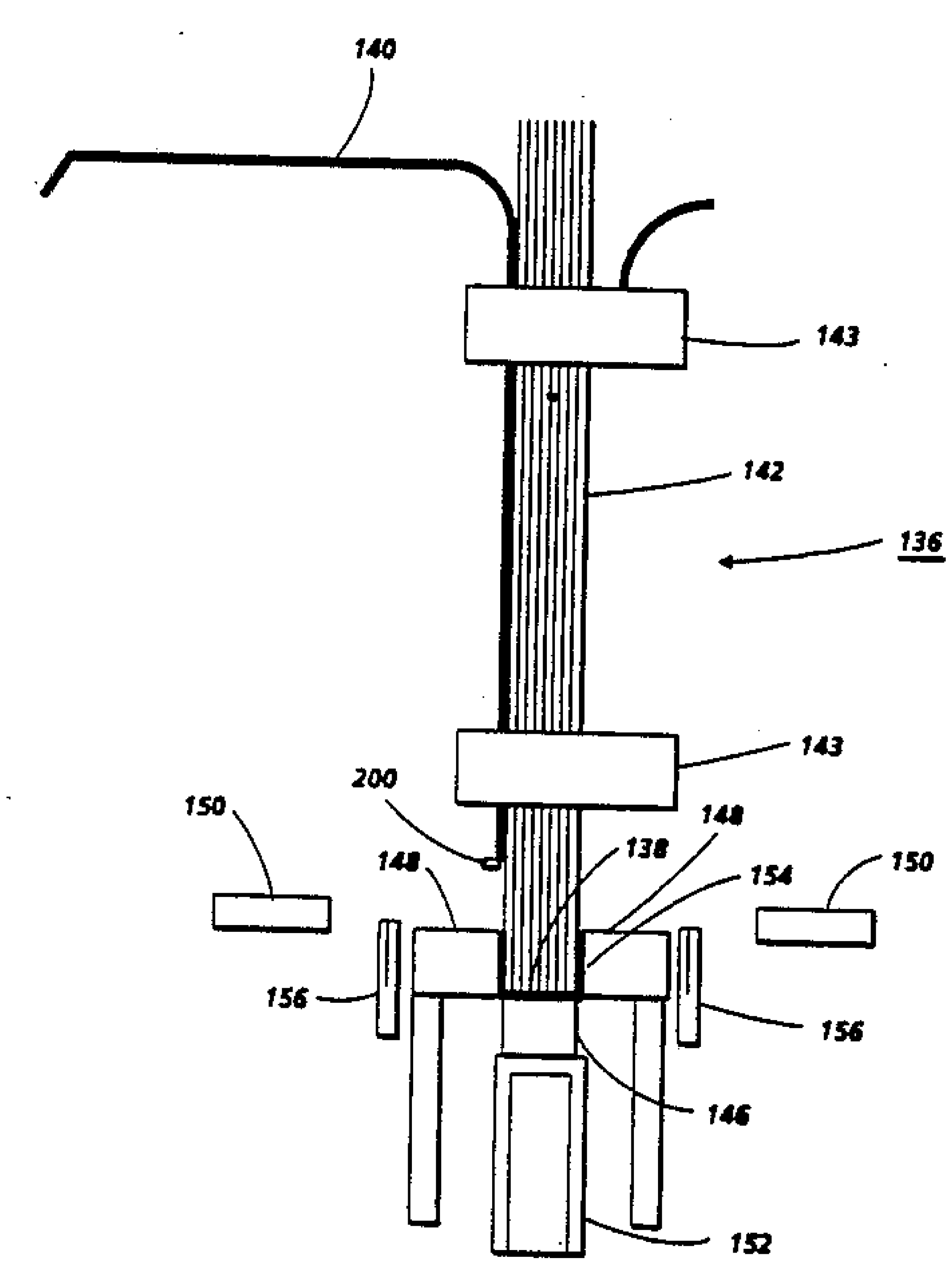
3,531,358	9/1970	Rost et al.	156/475
3,920,501	11/1975	Carlton et al.	156/364
3,926,712	12/1975	Wetzler et al.	156/477 B
3,928,119	12/1975	Sarring	156/477
4,184,218	1/1980	Hawkes	412/902
4,242,174	12/1980	Snellman et al.	412/37 X
4,564,185	1/1986	Hamlin et al.	156/908

Primary Examiner—David Simmons
Attorney, Agent, or Firm—H. Fleischer; J. E. Beck; R. Zibelli

[57] **ABSTRACT**

An apparatus which adhesively binds a set of sheets by applying a strip having an adhesive on one surface thereof to the spine of the set. The strip is supported on a heated platen which softens the adhesive. The spine of the set of copy sheets is pressed into the adhesive on the strip. The depth of penetration of the spine into the adhesive is controlled so as to form a layer of adhesive between the spine and the strip having a predetermined thickness.

6 Claims, 7 Drawing Sheets



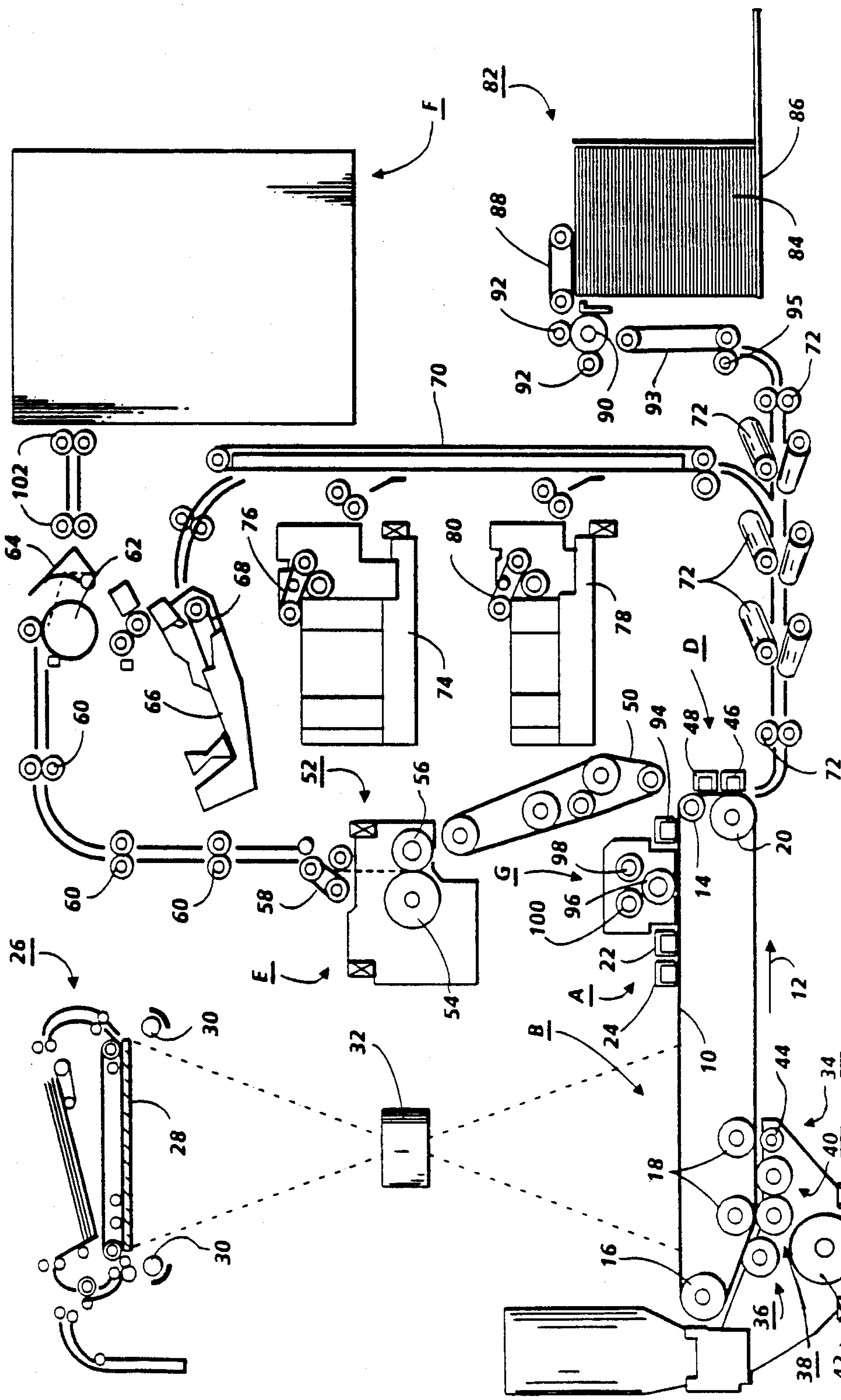


FIG. 1

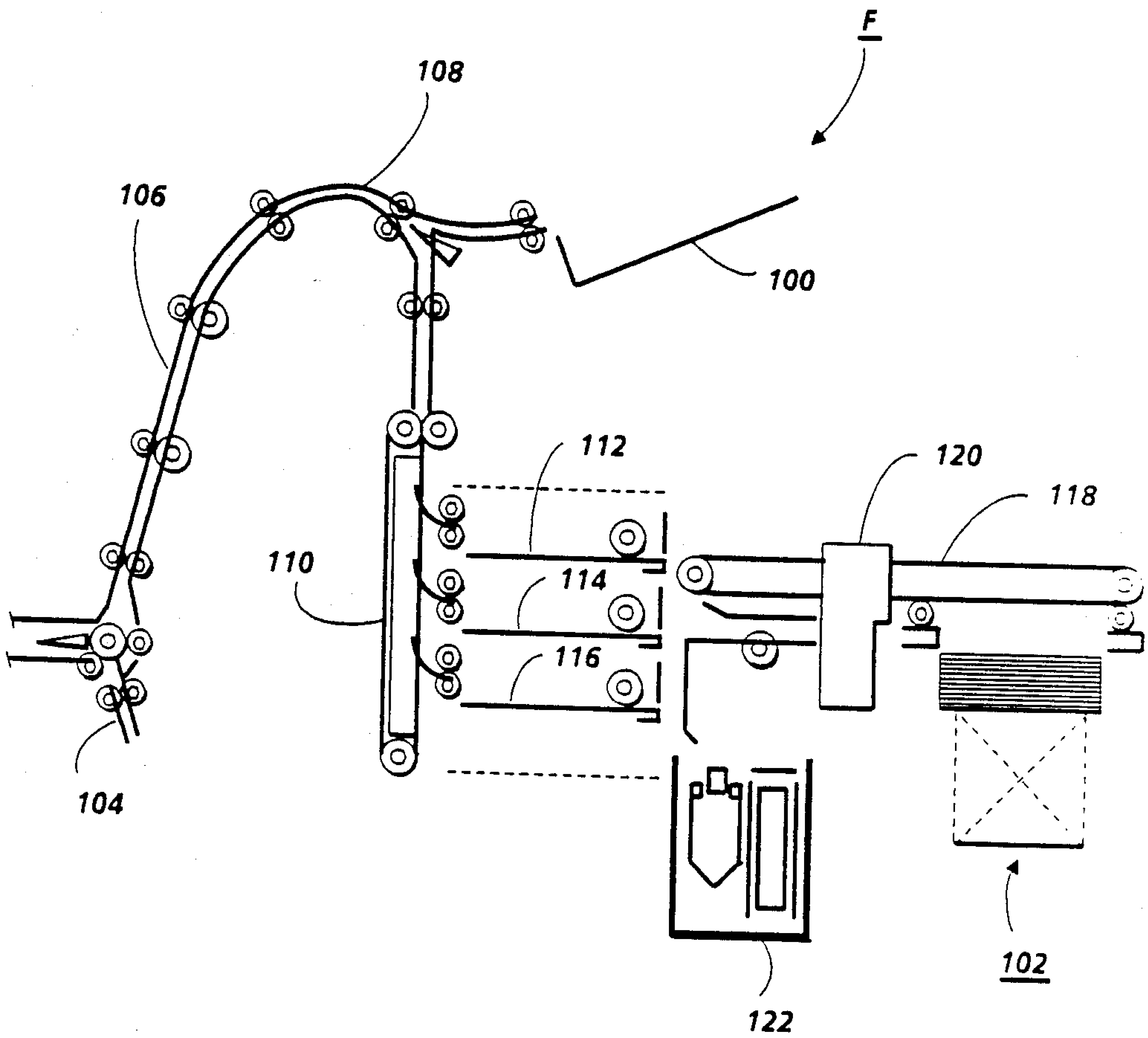


FIG.2

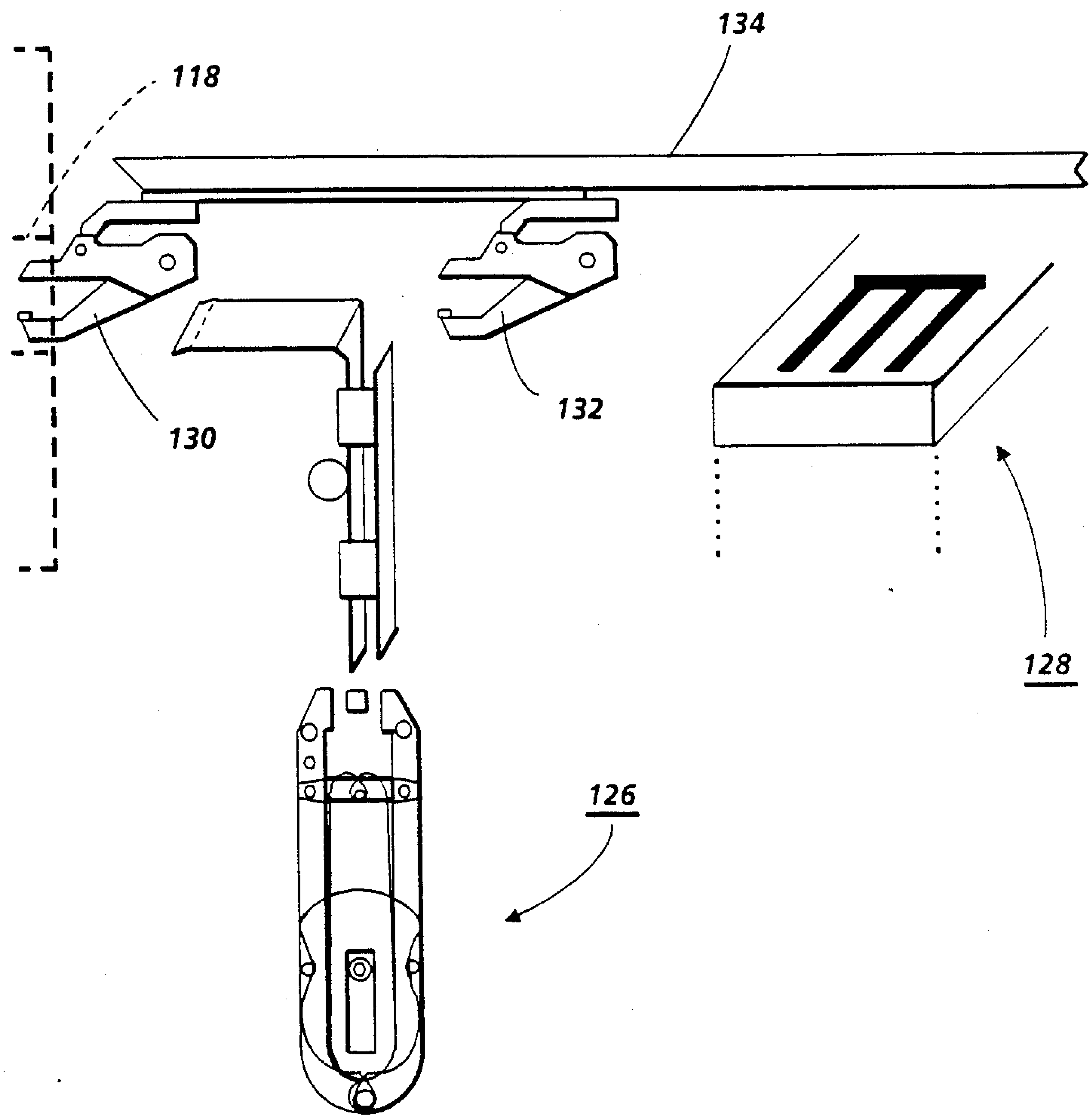


FIG. 3

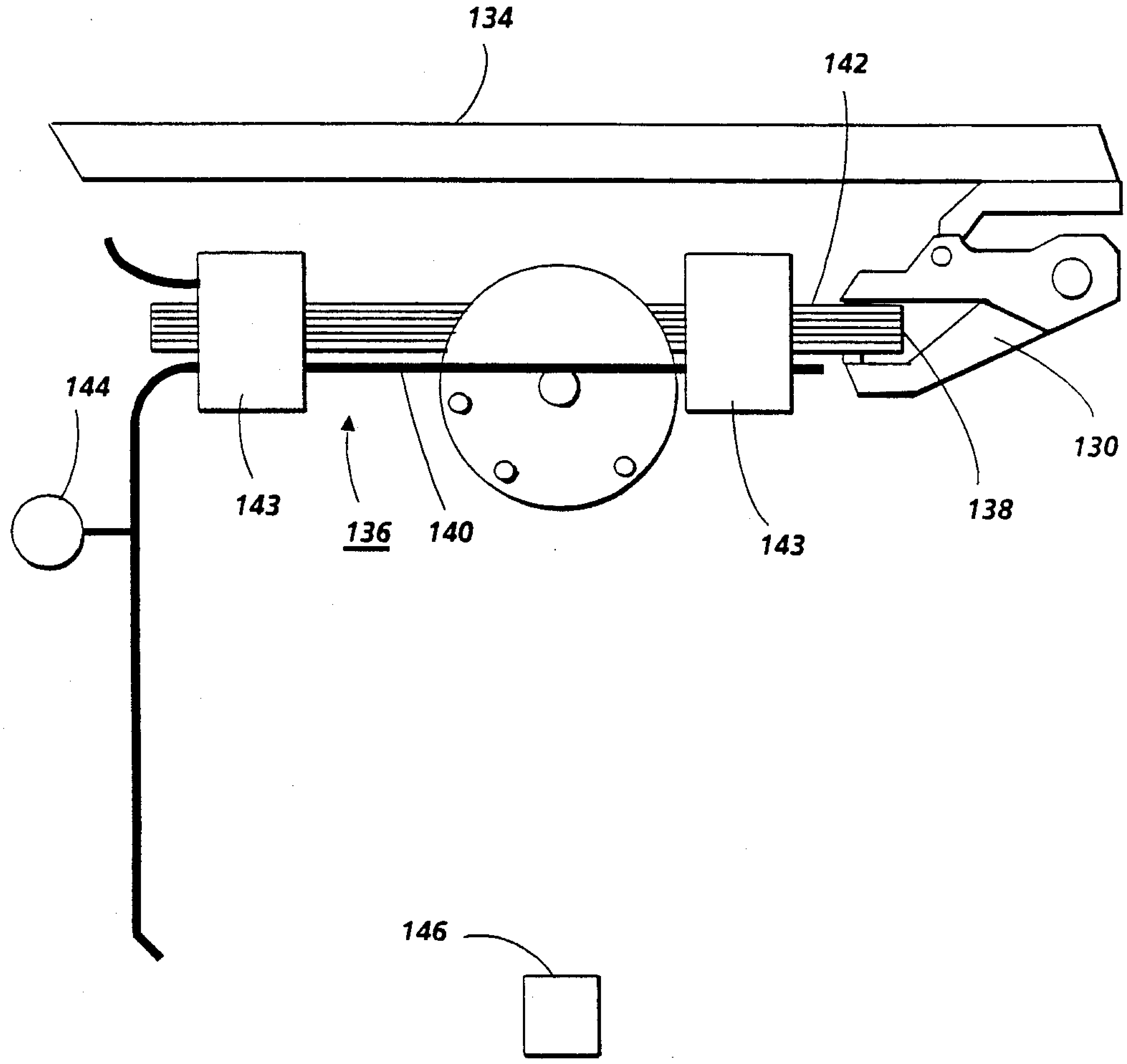


FIG. 4

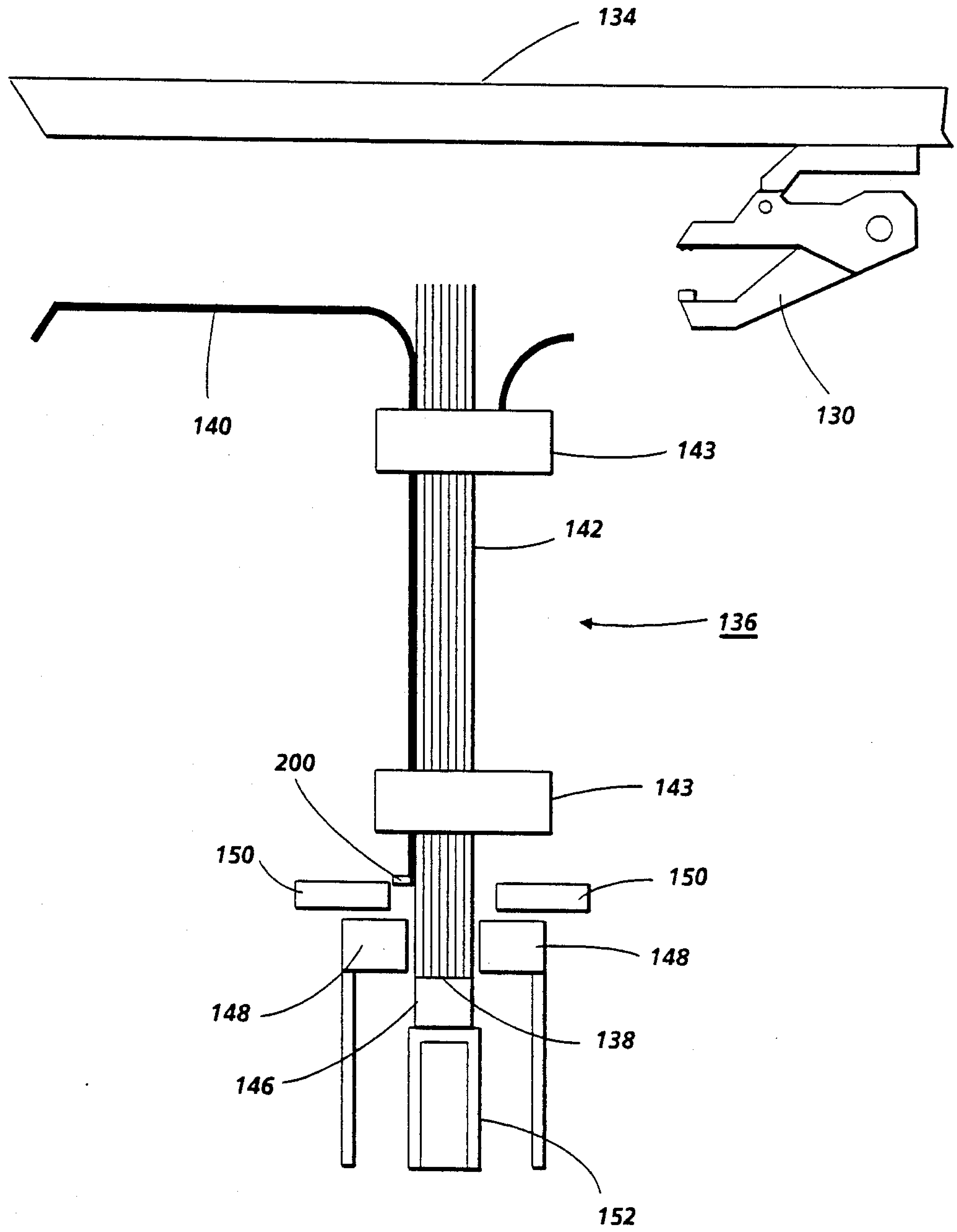


FIG. 5

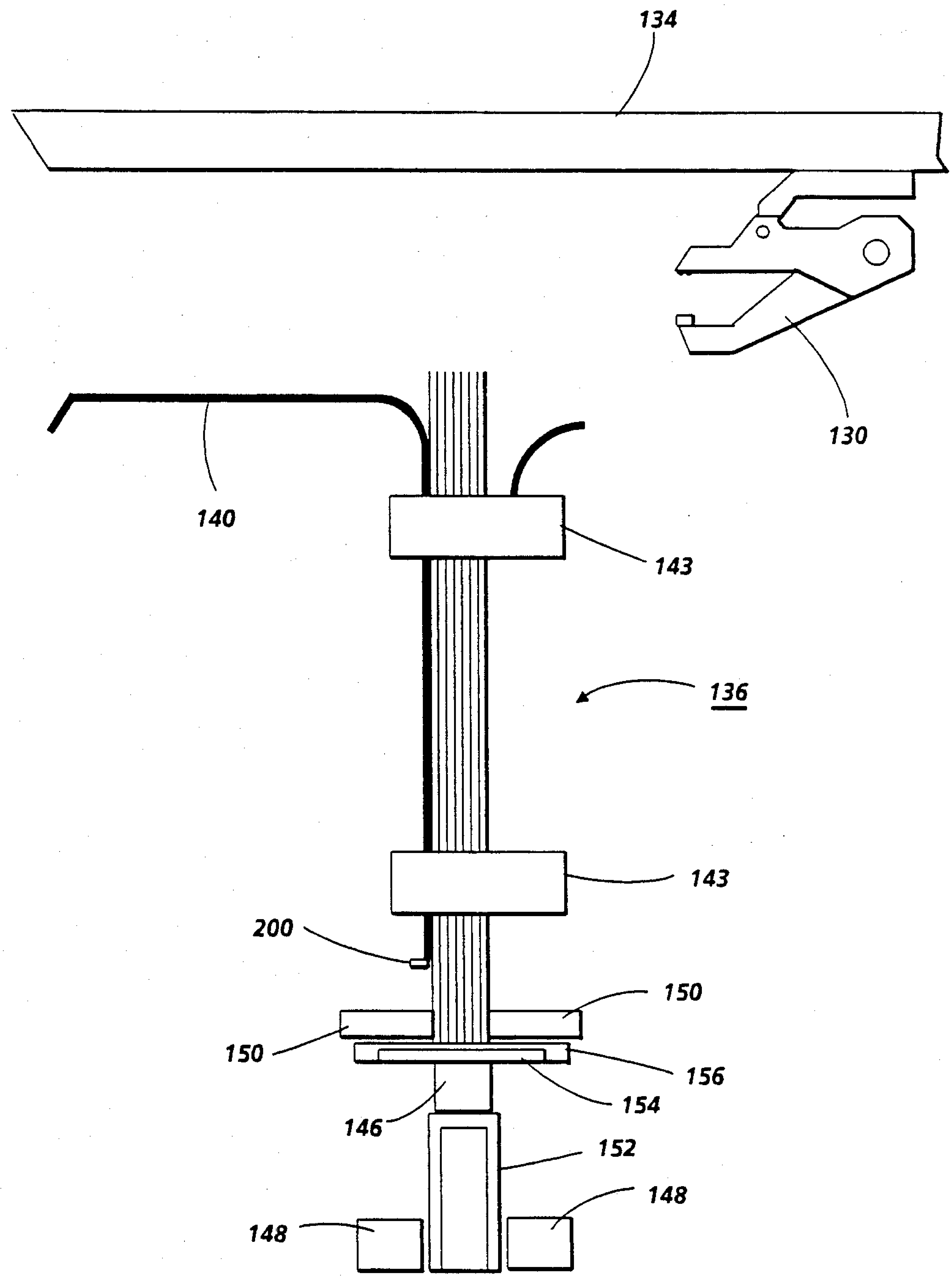


FIG. 6

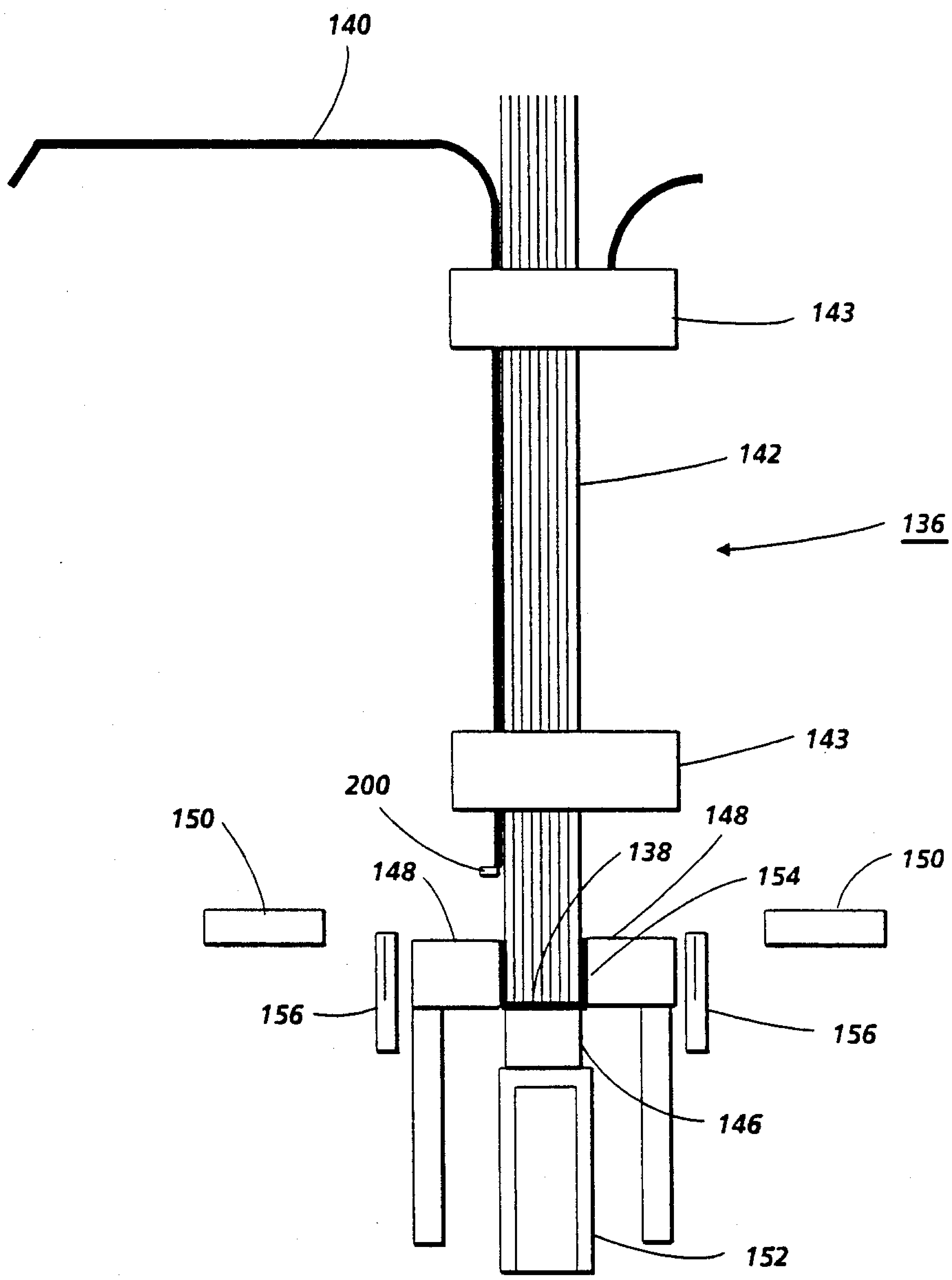


FIG. 7

BINDING APPARATUS

This invention relates generally to an electrophotographic printing machine, and more particularly concerns an apparatus for adhesively binding sets of finished copy sheets.

In a typical electrophotographic printing process, a photoconductive member is charged to a substantially uniform potential so as to sensitize the surface thereof. The charged portion of the photoconductive member is exposed to a light image of an original document being reproduced. Exposure of the charged photoconductive member selectively dissipates the charge thereon in the irradiated areas. This records an electrostatic latent image on the photoconductive member corresponding to the informational areas contained within the original document. After the electrostatic latent image is recorded on the photoconductive member, the latent image is developed by bringing a developer material into contact therewith. Generally, the developer material comprises toner particles adhering triboelectrically to carrier granules. The toner particles adhering triboelectrically to carrier latent image forming a toner powder image is then transferred from the photoconductive member to a copy sheet. The toner particles are heated to permanently affix the powder image to the copy sheet.

In a high speed commercial printing systems of the foregoing type, the copy sheets with the information permanently affixed thereto, are transported to a finishing station. After the requisite number of sheets, corresponding to a set of original documents is compiled in the finishing station, the copies of the set are permanently affixed to one another to form a booklet thereof. Most frequently, a stapling apparatus is employed to secure the sheet to one another to form the booklet. However, other alternative techniques have been used such as adhesively binding the sheets to one another. In order for each set of copy sheets to have a bond finished appearance, it is desirable to adhesively secure the sheets of the set to one another. Often, the printing machine employs a recirculating document handling system to advance successive original documents from a stack thereof to the exposure station of the electrophotographic printing machine for reproduction. When a recirculating document handling system is employed, the printing system produces a large number of copies rapidly. This type of system may be used to form sets or booklets of copy sheets. The copy sheets are collected and adhesive is applied to the spine to bind the sheets together into sets of copy sheets. The adhesively bound sets of copy sheets are then stacked for presentation to the machine operator. Numerous methods are known in the art for adhesively securing sheets to one another. For example, a liquid adhesive may be applied to the spine of a moving set of copy sheets, or the copy sheets may be stationary and a container having a supply of adhesive therein may be moved along the spine to apply the adhesive thereon. Alternatively, a tape having an adhesive on one surface thereof may be positioned in contact with the spine and heat applied thereto so as to cause the adhesive to flow between the sheets in the region of the spine securing the sheets together. When adhesive binding a set of copy sheets, it is desirable to maintain certain geometries with respect to adhesive thicknesses in order to form books which will have desirable characteristics. One such desirable characteristic is that the adhesively bound book should be capable of being bent back onto itself so that the covers on opposite sides touch with the region in the vicinity of the spine being flat. In order to insure that the adhesive does not fail along the spine, a finite amount of adhesive is required to be located on the end of each sheet, i.e. between the end of each sheet and the tape. Maintaining an adhesive layer of the correct thickness between the end of the set of copy sheets and the tape is a difficult problem in adhesive strip binders where the edge of the set of copy sheets and the adhesive strip are pressed together and heated. When pressure is applied to produce an efficient thermal transfer of heat from the heat source to the adhesive, this pressure will cause the adhesive to flow away from the region between the tape and end of the set of copy sheets. This will result in an inadequate amount of adhesive remaining between the edge of the set of copy sheets and the tape. Hereinbefore, this problem has been solved by adding a gauze of a suitable fiber in the adhesive to prevent the edge of the set of copy sheets from pushing all the adhesive from the region between the tape and the edge of the set of copy sheets. It is highly desirable to eliminate the need for this gauze. Various approaches have been devised for applying adhesive to the spine of the set of copy sheets. The following disclosures appear to be relevant:

U.S. Pat. No. 3,920,501, Patentee: Carlton et al. Issued Nov. 18, 1975.

U.S. Pat. No. 3,926,712 Patentee: Wetzler et al Issued: Dec. 16, 1975.

U.S. Pat. No. 3,928,119 Patentee: Sarring, Issued: Dec. 23, 1975.

The relevant portions of the foregoing patents may be summarized as follows:

U.S. Pat. No. 3,920,501 describes a sheet binding machine. After binding material is positioned in a predetermined area against pins and on a heated support surface, a single heated platen, which is movable, reaches an applying position to accomplish binding. Upon completion, the heated platen returns to its central or receiving position.

U.S. Pat. No. 3,926,712 discloses an apparatus for binding piles of sheets or leaves. Once the sheets to be bound are clamped, two hot plates are moved into position. One hot plate can be moved horizontally to clamp the edges of a stack while the other hot plate is movable in the vertical direction to press against the spine of the stack of sheets.

U.S. Pat. No. 3,928,119 describes a book binding machine in which a stack of sheets is held by a pair of movable support plates. Once a proper sized adhesive strip is inserted under the clamped stack, heated platens are moved toward each other. The stack of sheets is also moved downwardly into contact with a heated bottom platen. After applying heat for a predetermined time, the platens are removed and adhesive binding is achieved.

In accordance with one aspect of the present invention, there is provided an apparatus for binding a set of sheet by applying a strip having an adhesive on one surface thereof to one edge of the set. The apparatus includes means for supporting and heating the strip to soften the adhesive thereon. Means move the supporting means and the set of sheets relative to one another so as to press one edge of the set of sheets into the adhesive on the strip. Means are provided for controlling the depth of penetration of the edge of the set of sheets into the adhesive on the strip so as to form a layer of adhesive between the edge of the set and the strip having a predetermined thickness.

Pursuant to another aspect of the features of the present invention, there is provided an electrophotographic printing machine of the type in which successive copy sheets having indicia recorded thereon are compiled into sets and the sheets of each set are bound together by applying a strip having an adhesive on one surface thereof to one edge of the set. The improvement includes means for supporting and heating the strip to soften the adhesive thereon. Means move the supporting means and the set of sheets relative to one another so as to press one edge of the set of sheets into the adhesive on the strip. Means are provided for controlling the depth of penetration of the edge of the set of sheets into the adhesive on the strip so as to form a layer of adhesive between the edge of the set and the strip having a predetermined thickness.

Other aspects of the present invention will become apparent as the following description proceeds and upon reference to the drawings, in which:

FIG. 1 is a schematic elevational view depicting an illustrative electrophotographic printing machine incorporating the sheet binding apparatus of the present invention therein;

FIG. 2 is a schematic elevational view showing the finishing station of the FIG. 1 printing machine with the sheet binding apparatus;

FIG. 3 is a schematic elevational view further illustrating the FIG. 2 finishing station with the binding apparatus;

FIG. 4 is a schematic elevational view showing a set of copy sheets being received in the binding apparatus;

FIG. 5 is a schematic elevational view depicting the set of copy sheet being vibrated in the binding apparatus to register the edges thereof;

FIG. 6 is a schematic elevational view illustrating the binding apparatus positioning an adhesive strip on the spine of the set of copy sheets; and

FIG. 7 is a schematic elevational view showing the binding apparatus bending the sides of the adhesive strip into contact with opposed sides of the outermost sheets of the set of copy sheets.

While the present invention will hereinafter be described in connection with a preferred embodiment thereof, it will be understood that it is not intended to limit the invention to that embodiment. on the contrary, it is intended to cover all alternatives, modifications, and equivalents, as may be included within the spirit and scope of the invention as defined by the appended claims.

For a general understanding of the features of the present invention, reference is made to the drawings. In the drawings, like reference numerals have been used throughout to identify identical elements. FIG. 1 schematically depicts an electrophotographic printing machine incorporating the features of the present invention therein. It will become evident from the following discussion that the sheet binding apparatus of the present invention may be employed in a wide variety of devices and is not specifically limited in its application to the particular embodiment depicted herein.

Referring to FIG. 1 of the drawings, the electrophotographic printing machine employs a photoconductive belt **10**. Preferably, the photoconductive belt **10** is made from a photoconductive material coated on a ground layer, which, in turn, is coated on a anti-curl backing layer. The photoconductive material is made from a transport layer coated on a generator layer. The transport layer transports positive charges from the generator layer. The interface layer is coated on the ground layer. The transport layer contains small molecules of di-m-tolydiphenylbiphenyldiamine dispersed in a polycarbonate. The generation layer is made from trigonal selenium. The ground layer is made from a titanium coated Mylar. The ground layer is very thin and allows light to pass therethrough. Other suitable photoconductive materials, ground layers, and anti-curl backing layers may also be employed. Belt **10** moves in the direction of arrow **12** to advance successive portions of the photoconductive surface sequentially through the various processing stations disposed about the path of movement thereof. Belt **10** is entrained about stripping roller **14**, tensioning roller **16**, idler rollers **18**, and drive roller **20**. Stripping roller **14** and idler rollers **18** are mounted rotatably so as to rotate with belt **10**. Tensioning roller **16** is resiliently urged against belt **10** to maintain belt **10** under the desired tension. Drive roller **20** is rotated by a motor coupled thereto by suitable means, such as a belt drive. As roller **20** rotates, it advances belt **10** in the direction of arrow **12**.

Initially, a portion of the photoconductive surface passes through charging station A. At charging station A, two corona generating devices, indicated generally by the reference numerals **22** and **24** charge photoconductive belt **10** to a relatively high, substantially uniform potential. Corona generating device **22** places all of the required charge on photoconductive belt **10**. Corona generating device **24** acts as a leveling device, and fills in any areas missed by corona generating device **22**.

Next, the charged portion of photoconductive belt **10** is advanced through imaging station B. At imaging station B, a document handling unit, indicated generally by the reference numeral **26**, is positioned over platen **28** of the printing machine. Document handling unit **26** sequentially feeds documents from a stack of documents placed by the operator in the document stacking and holding tray. The original documents to be copied are loaded face up in the document tray on top of the document handling unit. A document feeder located below the tray forwards the bottom document in the stack to rollers. The rollers advance the document onto platen **28**. When the original document is properly positioned on platen **28**, a belt transport is lowered onto the platen with the original document being interposed between the platen and the belt transport. After imaging, the original document is returned to the document tray from platen **28** by either of two paths. If a simplex copy is being made or if this is the first pass of a duplex copy, the original document is returned to the document tray via the simplex path. If this is the inversion pass of a duplex copy, then the original document is returned to the document tray through the duplex path. Imaging of a document is achieved by two Xenon flash lamps **30** mounted in the optics cavity which illuminate the document on platen **28**. Light rays reflected from the document are transmitted through lens **32**. Lens **32** focuses light images of the original document onto the charged portion of the photoconductive surface of belt **10** to selectively dissipate the charge thereon. This records an electrostatic latent image on photoconductive belt **10** which corresponds to the informational areas contained within the original document. Thereafter, photoconductive belt **10** advances the electrostatic latent image recorded thereon to development station C.

At development station C, a magnetic brush developer unit, indicated generally by the reference numeral **34**, has three developer rolls, indicated generally by the reference numerals **36**, **38** and **40**. A paddle wheel **42** picks up developer material and delivers it to the developer rolls. When developer material reaches rolls **36** and **38**, it is magnetically split between the rolls with half of the developer material being delivered to each roll. Photoconductive belt **10** is partially wrapped about rolls **36** and **38** to form extended development zones. Developer roll **40** is a cleanup roll. Magnetic roll **44** is a carrier granule removal device adapted to remove any carrier granules adhering to belt **10**. Thus, rolls **36** and **38** advance developer material into contact with the electrostatic latent image. The latent image attracts toner particles from the carrier granules of the developer material to form a toner powder image on the photoconductive surface of belt **10**. Belt **10** then advances the toner powder image to transfer station D.

At transfer station D, a copy sheet is moved into contact with the toner powder image. First, photoconductive belt **10** is exposed to a pre-transfer light from a lamp (not shown) to reduce the attraction between photoconductive belt **10** and the toner powder image. Next, a corona generating device **46** charges the copy sheet to the proper magnitude and polarity so that the copy sheet is tacked to photoconductive belt **10** and the toner powder image attracted from the photoconductive belt to the copy sheet. After transfer, corona generator **48** charges the copy sheet to the opposite polarity to detack the copy sheet from belt **10**. Conveyor **50** advances the copy sheet to fusing station E.

Fusing station E includes a fuser assembly, indicated generally by the reference numeral **52** which permanently affixes the transferred toner powder image to the copy sheet. Preferably, fuser assembly **52** includes a heated fuser roller **54** and a pressure roller **56** with the powder image on the copy sheet contacting fuser roller **54**. The pressure roller is cammed against the fuser roller to provide the necessary pressure to fix the toner powder image to the copy sheet. The fuser roll is internally heated by a quartz lamp. Release agent, stored in a reservoir, is pumped to a metering roll. A trim blade trims off the excess release agent. The release agent transfers to a donor roll and then to the fuser roll.

After fusing, the copy sheets are fed through a decurler **58**. Decurler **58** bends the copy sheet in one direction to put a known curl in the copy sheet and then bends it in the opposite direction to remove that curl.

Forwarding rollers **60** then advance the sheet to duplex turn roll **62**. Duplex solenoid gate **64** guides the sheet to the finishing station F or to duplex tray **66**. The details of finishing station F will be described hereinafter with reference to FIG. **2**. Duplex solenoid gate **64** diverts the sheet into duplex tray **66**. The duplex tray **66** provides an intermediate or buffer storage for those sheets that have been printed on one side and on which an image will be subsequently printed on the second, opposed side thereof, i.e. the sheets being duplexed. The sheets are stacked in duplex tray **66** face down on top of one another in the order in which they are copied.

In order to complete duplex copying, the simplex sheets in tray **66** are fed, in seriatim, by bottom feeder **68** from tray **66** back to transfer station D via conveyor **70** and rollers **72** for transfer of the toner powder image to the opposed sides of the copy sheets. Inasmuch as successive bottom sheets are fed from duplex tray **66**, the proper or clean side of the copy sheet is positioned in contact with belt **10** at transfer station D so that the toner powder image is transferred thereto. The duplex sheet is then fed through the same path as the simplex sheet to be advanced to finishing station F.

Copy sheets are fed to transfer station D from the secondary tray **74** The secondary tray **74** includes an elevator driven by a bidirectional AC motor. Its controller has the ability to drive the tray up or down. When the tray is in the down position, stacks of copy sheets are loaded thereon or unloaded therefrom. In the up position, successive copy sheets may be fed therefrom by sheet feeder **76**. Sheet feeder **76** is a friction retard feeder utilizing a feed belt and take-away rolls to advance successive copy sheets to transport **70** which advances the sheets to rolls **72** and then to transfer station D.

Copy sheets may also be fed to transfer station D from the auxiliary tray **78**. The auxiliary tray **78** includes an elevator driven by a bidirectional AC motor. Its controller has the ability to drive the tray up or down. When the tray is in the down position, stacks of copy sheets are loaded thereon or unloaded therefrom. In the up position, successive copy sheets may be fed therefrom by sheet feeder **80**. Sheet feeder **80** is a friction retard feeder utilizing a feed belt and take-away rolls to advance successive copy sheets to conveyor **70** which advances the sheets to rolls **72** and then to transfer station D.

Secondary tray **74** and auxiliary tray **78** are secondary sources of copy sheets. A high capacity feeder, indicated generally by the reference numeral **82**, is the primary source of copy sheets. High capacity feeder **82** includes a tray **84** supported on an elevator **86**. The elevator is driven by a bidirectional motor to move the tray up or down. In the up position, the copy sheets are advance from the tray to transfer station D. A vacuum feed belt **88** feeds successive uppermost sheets from the stack to a take away drive roll **90** and idler rolls **92**. The drive roll and idler rolls guide the sheet onto transport **93**. Transport **93** and idler roll **95** advance the sheet to rolls **72** which, in turn, move the sheet to transfer station station D.

Invariably, after the copy sheet is separated from the photoconductive surface of belt **10**, some residual particles remain adhering thereto. After transfer, photoconductive belt **10** passes beneath corona generating device **94** which charges the residual toner particles to the proper polarity. Thereafter, a precharge erase lamp (not shown), located inside photoconductive belt **10**, discharges the photoconductive belt in preparation for the next charging cycle. Residual particles are removed from the photoconductive surface at cleaning station G. Cleaning station G includes an electrically biased cleaner brush **96** and two de-toning rolls **98** and **100**, i.e. waste and reclaim de-toning rolls. The reclaim roll is electrically biased negatively relative to the cleaner roll so as to remove toner particles therefrom. The waste roll is electrically biased positively relative to the reclaim roll so as to remove paper debris and wrong sign toner particles. The toner particles on the reclaim roll are scraped off and deposited in a reclaim auger (not shown), where it is transported out of the the rear of cleaning station G.

The various machine functions are regulated by a controller. The controller is preferably a programmable microprocessor which controls all of the machine functions hereinbefore described. The controller provides a comparison count of the copy sheets, the number of documents being recirculated, the number of copy sheets selected by the operator, time delays, jam corrections, etc. The control of all of the exemplary systems heretofore described may be accomplished by conventional control switch inputs from the printing machine consoles selected by the operator. Conventional sheet path sensors or switches may be utilized to keep track of the position of the documents and the copy sheets. In addition, the controller regulates the various positions of the gates depending upon the mode of operation selected.

Referring now to FIG. 2, the general operation of finishing station F will not be described. Finishing station F receives fused copies from rolls **102** (FIG. 1) and delivers them to solenoid actuated gate **110**. Gate **110** diverts the copy sheet to either registration rolls **104** or inverter **112**. A tri-roll nip is used to drive sheets into and out of the inverter. Inverter **112** has a compression spring which assists in reversing the direction of the sheets and assists in driving them out of the inverter. Inverter **112** is driven by a reversible AC motor. Two cross roll registration nips are used to register the sheets. The cross roll registration nips are driven by the sheet path drive motor. Rolls **104** advance the copy sheets to gate **114**. Gate **114** diverts the sheets to either the top tray **106** or to vertical transport **108**. Vertical transport **108** is a vacuum transport which transports sheets to any one of three bins **116**, **118** or **120**. Bins **116**, **118**, and **120** are used to compile and register sheets into sets. The bins are driven up or down by a bidirectional AC bin drive motor adapted to position the proper bin at the unloading position. A set transport **122** has a pair of set clamps mounted on two air cylinders and driven by four air valve solenoids. Two of the air valves are used for positioning the set transport and two are used for the retract function. The set transport is used to transport sets from the bins to sheet stapling apparatus **124**, binder **126** and sheet stacker **128**. The stapled, bound, or unfinished sets are delivered to stacker **128** where they are stacked for delivery to the operator.

Turning now to FIG. 3, there is shown the general operation of the sheet binding apparatus in the finishing station station. As shown, set clamps **130** and **132** are mounted on a set transport carriage **134** and pneumatically driven by a compressor. Set clamp **130** removes sets from bins **116**, **118** and **120**. These sets are delivered to binding apparatus **126**. Set clamp **132** removes the sets from binding apparatus **126** and delivers them to stacker **128**, where they are stacked for delivery to the operator. Set clamps **130** and **132** are mounted fixedly on carriage **134** and move in unison therewith. In operation, the clamps pick up their sets, as required, and move them to their release positions. They release their sets and begin to move to the home position. As the clamps move from the release position to the home position, a cam follower mechanism raises both clamps to insure that they can clear the stacks just delivered, on their return to their pick up position.

As shown in FIG. 4, set clamp **132** advances the set of copy sheets from bin **118** (FIG. 3) to a tilt bed, indicated generally by the reference numeral **136**, of binding apparatus **126**. Tilt bed **136** receives the set of copy sheets **142** from set clamp **130** and positions the set of copy sheets **142** for the binding operation. Once the binding operation is completed, tilt bed **136** retrieves the bound set of copy sheets **142** and positions them for pick up by the set clamp **132** (FIG. 3). Tilt bed **136** accepts sets of copy sheets **142** from set clamp **130**, with the spine **138**, i.e. the edge to be bound, leading, and controls the position of the set of copy sheets **142** during the binding operation. Tilt bed **136** includes a guide structure **140** with dual clamps **143** mounted thereon. Clamps **143** are spaced from one another and hold the set of copy sheets on guide structure **140**. The clamping action of clamps **143** is pneumatically driven through a solenoid. The required air pressure is provided by the Finisher compressor. Guide structure **140** is mounted on a pivoting shaft which allows it to rotate from a vertical position to a horizontal position. The guide structure **140** is oriented in a vertical position when non-operative, out of the path of the sets of copy sheets, until the bind feature on the control panel is selected. When the bind feature is selected, a 120 volt AC bidirectional motor **144** pivots guide structure **140** from the vertical position to the horizontal position. In the horizontal position, clamps **143** are in the open position to receive the set of copy sheets **142** from set clamp **130**. Clamps **143** clamp the set of copy sheets to the guide structure so as to move in unison therewith. Motor **144** pivots the guide structure **140** clockwise 90° in order to move the set of copy sheets **142** from the horizontal position to the vertical position for registration, as shown in FIG. **5**.

Referring now to FIG. **5**, tilt bed **136** is shown in the vertical position. When tilt bed **136** is in the vertical position, the two binder flappers **148**, on either side of the binder head **146**, move in an upward direction to form a channel, or U-shaped opening. Tilt bed **136** is moved in a downward direction until the lower portion of guide structure **140** engages a mechanical stop **200**. A sensor, preferably a light emitting diode and photodiode, detects the presence of the guide structure against stop **200** and de-energizes the motor moving the tilt bed in a downwardly direction. Mechanical stop **200** is preferably a pin mounted vertically movable so as to be adjustable from a first position for holding the guide structure during set registration to a second position, further from the surface of binder platen **146** for set binding. After the guide structure engages stop **200**, in the first position, the set of copy sheets is positioned in the U-shaped opening with edge **138** thereof abutting bind head **146**. At this time, clamps **143** open. Bind head **146** is a platen having a generally planar surface onto which the set of copy sheets is registered and which is internally heated for the binding process. Platen **146**, located between flappers **148**, serves as a fixed surface for registering the set of copy sheets, and as a source of heat for activating the glue on the adhesive tape when binding the set spine. Teflon is coated on the upper surface of platen **146** to reduce sticking of the tape thereto. The platen has two grooves extending from one side to the other side thereof. These grooves are located under the ends of the tape during the spine binding step to provide an air gap that limits the amount of heat transferred to the tape. This structure prevents molten glue from flowing from the ends of the tape producing an undesirable appearance defect. The platen also has four side protrusions which prevent sheets from falling between the flappers and the platen during registration. Flappers **148** limit set spreading during registration, form the flaps in the adhesive tape during folding of the adhesive tape flaps or sides, and press and heat the tape flaps onto the top and bottom sheets or covers of the set of copy sheets. The flappers are moved by cams driven by a **120** volt AC unidirectional motor connected to a cam shaft. At the start of each cycle, the cams rotate for a segment to drive the flappers up for set registration and then drive the flappers down when registration is completed. During the next segment of cam rotation, the cam raises the flappers up. Springs, attached to the cam arms, pull the flappers in to press the sides of the adhesive tape against the outermost sheets of the set for binding. The flappers also pivot the spring loaded tape guides out of the way. Another set of cams changes the path of the flappers when opening from a bound set. The high point of these cams push up on a follower which raises the flappers away from the bound set to break any seal between the heated flappers and the set. Platen **146** and flappers **148** each have an internal resistive AC powered heating element. Thermistors are used to monitor the operating temperature of the platen and flappers. Calipers **150** are air actuated paper clamps mounted above the flappers. The calipers are used to straighten the set of copy sheets at the completion of registration and during the spine bind cycle. Air pressure presses the calipers against the set of copy sheets while the set is in contact with the adhesive tape during the bind operation and before the flappers are raised for binding the tape to the set sides in order to reduce flaring of sheets near the binding edge. A vibrator, indicated generally by the reference numeral **152**, is attached to the underside of platen **146**. Vibrator **152** includes an AC power supply which drives a solenoid coupled to platen **146**. Vibrator **152** vibrates platen **146** at two frequencies for two levels of vibration force. When the set of copy sheets is initially positioned in contact with platen **146**, vibrator **152** vibrates platen **146** at full force, i.e. at **50** volts and **60** hertz. For the remainder of the registration cycle, the set of copy sheets is vibrated at half force, i.e. at 100 volts and 120 hertz. Two levels of force applied in this manner yield better registration than a single level of vibration force. After registration of the copy sheets is completed, clamps **143** of tilt bed **136** close and the tilt bed moves in a vertically upward direction to space edge **138** of set **142** from platen **146** and a tape **154** having adhesive on one surface thereof is interposed between platen **146** and spine **138** of set **142**. The surface of the tape having the adhesive thereon is positioned to contact the spine of the set of copy sheets. This is shown more clearly in FIG. **6**.

Referring now to FIG. **6**, while tilt bed **136** raises the set of copy sheets **142**, flappers **148** lower in preparation for receiving the adhesive tape. A tape feeder, driven by a stepper motor, controls the tape size for the bind. The motor advances a length of tape corresponding to the length of the copy sheet edge having the tape applied thereon. The tape is then fed into tape guide **156** and, cut to size, and positioned in tape guide **156**. Tape guide **156** is then moved over platen **146** and flappers **148**. At this time, calipers **150** press against the sides of the set of copy sheets.

Turning now to FIG. **7**, stop **200** is shown in the second position further from the surface of platen **146**. Platen **146** and flappers **148** are heated to soften the adhesive. After the tape is positioned over the platen and flappers, the motion of tape guide **156** moves stop **200** upwardly to the second position. In the second position, stop **200** engages the lower end of guide structure **140** with edge **138** of set **142** pressed into the softened adhesive on tape **154** a distance sufficient to form a layer of adhesive having a thickness of about **0.254** millimeters between edge **138** and the surface of tape **154** opposed therefrom. Another sensor, preferably a light emitting diode and a photodiode, detects when the end of guide structure **140** engages stop **200** and de-energizes the motor moving tilt bed **136** downwardly. Thus, after stop **200** is positioned in the second position, tilt bed **136** moves in a downwardly direction until the end of guide structure **140** contacts stop **200** to press spine **138** into the softened adhesive on tape **154**. Stop **200** is located in the second position so that a layer of adhesive having a thickness of about **0.254** millimeters, is formed between spine or end **138** and the surface ot tape **154** opposed therefrom. Calipers **150** are disengaged from the set of copy sheets and flapper **148** moves in a vertically upward direction to bend tape **154** so that the adhesive side thereof presses against opposed outermost sheets of the set of copy sheets. Preferably, flappers **148** and platen **146** are heated to about 265° F. and 425° F., respectively, to thermally activate and soften the adhesive on tape **154**. In this way, the adhesive tape is fixed to the spine of the set of copy sheets with a layer of adhesive being formed between the spine and surface of the tape opposed therefrom having a predetermined thickness of about **0.254** millimeters. One skilled in the art will appreciate that the selected predetermined thickness may vary and is not limited to **0.254** millimeters as this thickness may not be optimum for all conditions. Any suitable adhesive tape known in the binding art may be employed. One such adhesive tape is described in U.S Pat. No. 3,847,718, the relevant portions thereof being hereby incorporated into the present application by reference thereto. After the adhesive tape is applied on the spine of the set of copy sheets, the flappers are retracted and the tilt bed moves in a vertically upward direction to space the bound set of copy sheets from platen **146**. Tilt bed **136** then rotates 90° in a counter clockwise direction to position the set of copy sheets in a substantially horizontal orientation. Set clamp **132** then receives the bound edge of the set of copy sheets and transports the set of copy sheets to stacker **128** for subsequent removal from the finishing station by the machine operator. A set of copy sheets bound in this manner may have the covers thereof bent back into contact with one another with the spine region being flattened without the sheets separating therefrom.

In recapitulation, the tilt bed of the binding apparatus receives the set of copy sheets and pivots the set of copy sheets from a horizontal plane to a vertical plane. Side flappers move upwardly to define a U-shaped space. The tilt bed moves the set of copy sheets downwardly into the U-shaped space until the tilt bed engages a mechanical stop and the spine edge of the set contacts the binder platen. The binder platen is then vibrated to register the sheets of the copy set with one another. The flappers are than retracted, and the tilt bed spaces the spine edge of the registered sheets of the set from the binder platen. Adhesive tape is interposed between the binder platen and the spine of the set of copy sheets. The tilt bed moves the set of copy sheets downwardly until the end thereof contacts the stop. The stop has moved to a second position, further from the binder platen. When the end of the tilt bed contacts the stop, the spine of the set of copy sheets is pressed into the heated, softened adhesive forming a layer of adhesive between the spine and the surface of the tape opposed therefrom having a predetermined thickness. The flappers move upwardly to bend the tape so that the heated, softened adhesive contacts the outermost sheets of the set. Thereafter, the tilt bed returns the set of copy sheets to the horizontal position where the set clamp receives the bound set of copy sheets and moves it to the stacker for removal by the machine operator.

It is, therefore, evident that there has been provided, in accordance with the present invention, a sheet binding apparatus that fully satisfies the aims and advantages hereinbefore set forth. While this invention has been described in conjunction with a preferred embodiment thereof, it is evident that many alternatives, modifications, and variations will be apparent to those skilled in the art. Accordingly, it is intended to embrace all such alternatives, modifications and variations as fall within the spirit and broad scope of the appended claims.

I claim:

1. An electrophotographic printing machine of the type in which successive copy sheets having indicia recorded thereon are compiled into sets and the sheets of each set are bound together by applying a strip having adhesive on one surface thereof to one edge of the set, wherein the improvement includes:

means for stationarily supporting and heating the strip to soften the adhesive thereon;

means for moving the set of copy sheets relative to said supporting means so as to press one edge of the set of copy sheets into the adhesive on the strip; and

means for limiting the movement of said moving means to regulate the depth of penetration of said one edge of the set of copy sheets into the adhesive on the strip so as to form a layer of adhesive between said one edge of the set and the strip having a predetermined thickness.

2. A printing machine according to claim 1, wherein said supporting means includes a heated platen defining a generally planar, substantially horizontal support surface.

3. A printing machine according to claim 2, wherein said moving means orients the set of copy sheets substantially vertically and moves the set of copy sheets in a downward direction.

4. A printing machine according to claim 3, further including a pair of heated side guides arranged to be normally spaced from the set of copy sheets and being mvoable to fold the sides of the strip into contact with opposed outer sheets of the set of copy sheets and heat the sides of the strip to fix the sides of the strip to the opposed outer sheets of the set of copy sheets.

5. A printing machine according to claim 4, wherein said limiting means includes at least one stop for limiting the movement of said moving means.

6. A printing machine according to claim 5, wherein said stop limits the penetration of said one edge of the set of copy sheets into the adhesive of the strip so that the layer of adhesive between said one edge of the set and the strip has a thickness of about 0.254 millimeters.

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